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ABSTRACT

Reported is a study to investigate the performance of students enrolled in a general education program in the natural sciences. Part of the purpose of the study was to investigate a locally-developed evaluation instrument, SMAT. The SMAT is designed to examine a student's concept of the scientific method. Data are reported relative to factors significant to predicting the student's instrument score, course grade, and college grade point average. (PB)

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Techniques Used to Analyze A General Education Program in the Natural Sciences

II. A Preliminary Examination of the Scientific Method and Other Factors as Related to Success in Introductory Science Sequences

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Introduction

Within the framework of an introductory science curriculum many colleges and universities require a two quarter or two semester sequence for graduation. These courses are generally required to have an associated laboratory experience, the purpose of which is to acquaint the student with the scientific method, as well as illustrate and demonstrate the concepts of the curriculum.

One of the purposes of this study is to investigate performance on a locally developed instrument, SMAT, (Halyard and Pridmore, 1979) and other factors that traditionally have been found to be predictors of success in introductory college science sequences. Among these factors are: number of hours of college science completed; number of hours of college mathematics completed; college grade point average; SAT or ACT test scores; and age.

Many previous studies investigated factors influencing achievement in college science sequences at the introductory level. Literature is reported in this study from introductory biology, chemistry, and physics. The authors make no claim as to completeness, merely offering these as representative examples from the literature.

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SAT or ACT standardized tests were reported to be significant predictors of success in studies by Blumenthal (1961), Fulwood (1966), Hendricks (1969), Chesson (1975), and Pridmore (1979) to cite only a few representing the three aforementioned subject areas. Previous science background was a reported factor in studies by Bolte (1966) and Witten (1968).

College mathematics preparation was reported to be a significant predictor in a study by Foster (1938). Woodward (1963) and others reported college grade point average to be a significant predictor. Many of the cited studies find the same reported factors although each study is acknowledged only once.

Other problems addressed in this study include the factors before mentioned as they might relate to success using the scientific method as measured by SMAT. Also, the measures were used to check the relationship to the college grade point average as the dependent variable.

Method

The sample included in this study consists of 306 students who had completed their first science sequence (ten quarter hours credit) at an institution within the University System of Georgia during the Winter and Spring quarters of 1979. The institution, a junior college, offers sequences in biology, chemistry, and physics.

Students who were completing their second or third sequence were excluded from the study to reduce test learning as well as repeated competency mastery.

SMAT was administered to all students in the second course of a laboratory science sequence during the last week of the class. In addition, at the end of the course, the following information was gathered from student records: number of quarter credit hours of college laboratory science completed; number of quarter credit hours of college mathematics completed; total number of college

credit hours completed; whether or not any non-laboratory science courses were taken; college grade point average; course grade; SAT score (combined part scores); and age.

The data were analyzed by means of stepwise multiple regression analysis using the BMD-02R program (Dixon, 1970). Four subproblems were run on each of two samples. The first sample consisted of all 306 students but without using SAT score as an independent variable. This was done since SAT information was not available on forty-six students who had transferred to the institution. The second sample was the 260 students for which all information was available.

The subproblems examined on each were:

1. all factors included, using SMAT as the dependent variable;
2. all factors included, using course grade as the dependent variable;
3. all factors included, using college grade point average as the dependent variable; and
4. force deleting college grade point average, using the other factors with the course grade as the dependent variable.

All tests of significance were conducted at the .05 level.

Results

A summary of the data is presented in Table 1 for the subsample having all information available. Several points about the sample are noted here. The "average" student completing the science sequence is a first quarter sophomore (college hours equal 52.8) having a college grade point average of 2.36. The mean grade received in the second course of the sequence was "C". The typical student was 22.3 years old and had a composite SAT score of 889.

Table 2 presents the correlation matrix for the all factors present sample. The critical value is $r_{.05,200}=0.138$. From the table it can be seen that SMAT

has significant correlations with science hours, course grade, total college hours, college grade point average, college mathematics, and SAT scores. The course grade correlates significantly with all factors except age, non-laboratory science experience, total hours earned, and the amount of college mathematics. The only factor present which does not show significance with the college grade point average is the non-laboratory science course.

Subproblem one (SMAT as dependent variable)

Sample including all factors (n=260)

Factors that enter the regression equation significant at the .05 level ($F_{.05,1,200}=3.89$) are total SAT score (F=175.7), college grade point average (F=11.6), and non-laboratory science experience (F=8.1).

These factors account for forty-five percent of the variance within SMAT. The standard error of estimate is 3.96 on the 40 point scale.

Sample exclusing SAT (n=306)

Factors that are significant as they enter the regression analysis are college grade point average (F=71.5), college mathematics (F=9.1), and age (F=4.2).

The regression equation accounts for only 22% of the variance while having a standard error of estimate of 4.81.

Tables 3 and 4 give summaries of the steps within the regression analysis for subproblem one.

Subproblem two (Grade as dependent variable)

Sample including all factors (n=260)

The regression equation computed contained the factors of college grade point average (F=350.1), age (F=4.4), and college mathematics (F=4.3). The regression coefficients for age and college mathematics were both negative.

Fifty nine percent of the variance was accounted by these factors with a standard error of estimate equal to 0.7 on a 4.0 scale.

Sample excluding SAT (n=306)

As the regression analysis was carried out without SAT on grade within the course, the college grade point average accounted for fifty eight percent of the variance. The factors of age and college mathematics were significant when considered in tandem with grade point average. However their significance appeared to be statistical only. The increase in variance accounted for by the addition of these two factors was only one percent.

Subproblem three (GPA as dependent variable)

Sample including all factors

In computing a regression equation for college grade point average 68% of the variance could be accounted by the factors of course grade (F=350.1), total SAT score (F-44.5), age (F-21.0), SMAT score (F=6.4), and college mathematics background (F=5.0). A standard error of estimate of 0.39 on a 4.0 scale was computed.

Sample excluding SAT scores

The factor of course grade (F=418.6), SMAT scores (F=43.6), age (F=9.3), and college mathematics (F=6.0) combine to account for 65% of the variance with a standard error of estimate calculated to be 0.42.

Tables 5 and 6 summarize subproblem three for all factors.

With subproblem four it proved to be impossible to account for more than twelve percent of the variance within the course without the college grade point average due to the high correlation (r=0.759) between the college grade point average and the course grade.

Conclusions

The study found that students were achieving competency in the scientific method, as measured by SMAT, at the seventy percent level. However, this did not prove to be a significant factor in predicting the course grade. Although the scientific method is presented and used within the framework of the course (most notably in the laboratories), the majority of the grade in a specific course is a result of subject-specific concepts. An alternate method of testing the scientific method and its possible influences on course achievement would be to develop specific examinations that relate the concepts of the sequence being taken and the scientific method.

Currently under investigation is a study that seeks the factors that influence performance in introductory laboratories at the same institution (Halyard, Pridmore, and Carpenter, 1979). The study is at present involved only with introductory biology. If the results prove fruitful it is possible that it can be expanded to all three sciences in the future. One can only theorize that the scientific method might show as a significant factor more readily in that study than in this.

Concerning other factors that might be significant in determining course grades in a science sequence, the study found as did previous research that the college grade point average (if available) is the single best predictor. Interestingly, other significant factors (college mathematics and age) had negative coefficients in the regression analysis. The finding as to age might appear to be explained by the length of time since previous science courses, if any, in high school. The result on college mathematics is curious and perhaps worthy of future investigation.

As reported in part I of this study, SMAT was developed only for the

scientific method, not specific scientific concepts. Subsequent pre-testing of a later sample has revealed that the gain in achievement on SMAT is perhaps minimal within a given sequence. Future consideration needs be given to testing at lower grade levels to ascertain the level at which the scientific method is noticeably acquired.

If one were to set significant competence in the scientific method as a sequence goal, the data supports the achievement of the goal at the institution. If, however, the goal is to significantly develop the scientific method as a direct result of the sequences taught, the results cannot support or refute the finding as it now stands.

It is interesting to note the parallel between SMAT and SAT scores although SMAT was not intended to measure the same qualities. The partial correlation of the two ($r=0.637$) is high. The role in the regression analysis of college grade point average is the same for SMAT in the subsample without SAT scores as it is for SAT scores in the all factors present subsample.

Perhaps the "wheel" has been reinvented. In striving to develop an instrument that is void of subject specificity, the factors ultimately tested could be other than those proposed in the test development. Factor analysis is currently being used to examine SMAT toward this end. At this time all that can be reported is that other clusters of factors are not readily apparent.

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Table 1

Summary of Data for Subsample Having All Factors Available

Variable	Mean	Standard Deviation	Scale
SMAT	28.2	5.3	0-40
Science hours	10.6	3.0	actual (quarter hours)
Age	22.3	5.6	actual (years)
Non-lab science	0.6	1.6	0,5
Course grade	2.0	1.1	0-4.0
College hours	52.8	24.1	actual (quarter hours)
College GPA	2.4	0.7	0-4.0
College math	6.3	6.0	actual (quarter hours)
SAT (combined)	888.8	161.9	400-1600

n=260

Table 2

Correlation Matrix

Factor	SMAT	SCIHRS	AGE	NONLAB	GRADE	COLHRS	COLGPA	MATH	SATTOT
SMAT	1.000	0.155	0.004	0.057	0.283	0.159	0.438	0.227	0.637
SCIHRS		1.000	0.113	0.058	0.189	0.207	0.203	0.071	0.102
AGE			1.000	0.279	0.050	0.357	0.176	-0.078	-0.067
NONLAB				1.000	0.037	0.415	0.058	-0.082	-0.150
GRADE					1.000	0.118	0.759	0.074	0.297
COLHRS						1.000	0.225	0.461	0.056
COLGPA							1.000	0.191	0.464
MATH								1.000	0.251
SATTOT									1.000

$r_{.05,200}=0.138$

Table 3

Summary Table of Variable Entry Using SMAT as Dependent Variable*

Step Number	Variable Entered	Multiple R	Multiple RSQ	F Value to Enter
1	SATTOT	0.637	0.405	175.7**
2	COLGPA	0.656	0.431	11.6**
3	NONLAB	0.670	0.448	8.1**
4	MATH	0.673	0.452	1.9
5	SCIHRS	0.675	0.455	1.4
6	GRADE	0.675	0.456	0.2
7	AGE	0.675	0.456	0.1

* All factors present

n=260

$F_{.05,1,200}=3.89$

** $p < .05$

Table 4

Summary Table of Variable Entry Using SMAT as Dependent Variable*

Step Number	Variable Entered	Multiple R	Multiple RSQ	F Value to Enter
1	COLGPA	0.436	0.190	71.5**
2	MATH	0.463	0.214	9.1**
3	AGE	0.474	0.225	4.2**
4	GRADE	0.479	0.230	1.9
5	SCIHRS	0.481	0.231	0.7
6	NONLAB	0.483	0.233	0.6
7	COLHRS	0.484	0.234	0.5

* SAT score not present

n=306

$F_{.05,1,200}=3.89$

** $p < .05$

Table 5

Summary Table of Variable Entry Using Grade Point Average as Dependent*

Step Number	Variable Entered	Multiple R	RSQ	F Value to Enter
1	GRADE	0.759	0.576	350.1**
2	SATTOT	0.799	0.638	44.5**
3	AGE	0.816	0.666	21.0**
4	SMAT	0.821	0.674	6.4**
5	MATH	0.824	0.680	5.0**
6	COLHRS	0.825	0.681	0.6
7	SCIHRS	0.825	0.681	0.2
8	NONLAB	0.825	0.681	0.0

* All factors present

n=260

$F_{05,1,200}=3.89$

** $p < .05$

Table 6

Summary Table of Variable Entry Using Grade Point Average as Dependent*

Step Number	Variable Entered	Multiple R	RSQ	F Value to Enter
1	GRADE	0.761	0.579	418.6**
2	SMAT	0.795	0.632	43.6**
3	AGE	0.802	0.643	9.3**
4	MATH	0.806	0.650	6.0**
5	NONLAB	0.807	0.650	0.1
6	COLHRS	0.807	0.650	0.0

* SAT scores not present

n=306

$F_{.05,1,200}=3.89$

** $p < .05$